Abamectin Dislodgeable Foliar Residues Following Reduced-Volume and Conventional Pesticide Applications in a Greenhouse

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Summary

Low volume spray technology has been shown to increase dislodgeable foliar residues[2] when applied at the same rate of active ingredient per acre. Higher foliar residues have shown the potential to increase exposure to workers entering treated areas[8]. Dislodgeable foliar residues (DFR) of abamectin were monitored following a low volume air-assisted electrostatic spray (ES) application. This application was compared with DFR monitoring of a conventional full coverage spray applied with a high volume of water. Both applications were applied using hand wands designed for their respective sprayers. Applications were conducted in one greenhouse raising gerbera flowers for floral use. The ES application rate was 0.0058 pounds active ingredient in 2.5 gallons of water. The conventional sprayer applied 0.0094 pounds active ingredient in 100 gallons of water. DFR samples were collected. Both applications yielded very low foliar residues. The mean deposition four hours post application for the ES treatment was 0.002 $\mu g/cm^2$ and for the conventional treatment 0.035 $\mu g/cm^2$. Half-life data for the two applications was similar at 1.5 days. Lower residues for the ES application may be attributed to 60% less abamectin applied over the treatment area and poor penetration of the dense plant foliage using the ES technology. Foliar residues using ES technology were considerably less than conventional residues. In this study the conventional application applied as a full coverage spray to just before material runoff on leaves yielded higher dislodgeable foliar residues in the dense basal tufted leaves of the gerbera plant.

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Introduction

Traditionally, nursery greenhouse pesticide applications have used spray equipment requiring high volume and high-pressure sprays. However, spray technology has changed and spray equipment is now available that uses less volume and often at lower pressure. Measurements of spray efficiencies have been described and discussed elsewhere[1,2,3]. Hall (1991)[3], in a comprehensive review found, "in general a close relationship between drop size, drop density, concentration, and their effect upon pest mortality, i.e., small (drop size) is usually more effective on an array of pests." "This relationship can be dependent upon both the pest species, its ecology, and the specific attributes of the pesticide and its formulation." Droplets less than 100 µm were deposited more efficiently on the lower leaves. The number and size of droplets may have as much or more to do with insect control than the amount of actual toxicant in a given area. Many low volume sprayers produce droplets in this lower range. Electrostatic nozzles produce smaller droplets and put a slight negative charge on each spray droplet. While the plant is considered neutral because it is in the ground there are slight positive charges on the plant surface. Additionally since the charged droplets have the same polarity they repel each other and do not coalesce, allowing for better distribution within the target area. Studies[4,5,6] have shown an increase in pesticide deposition and pest control efficacy using charged droplet spray technology. Giles et al. (1992)[2], compared reduced-volume electrostatic spray (ES) technology to a conventional application (full coverage spraying to just before material runoff on leaves) in a greenhouse using the same application rate of one pound of active ingredient per acre. The results showed a greater than 3-fold increase in foliar deposition using the reduced-volume ES application. Increases in foliar deposition can potentially lead to increases in worker exposure while performing cultural practices. These increases can be measured by sampling for dislodgeable foliar residues (DFR). These are residues that can be removed by washing the surface of the leaf with a water and surfactant solution. DFR is expressed as micrograms per square centimeter of leaf surface ($\mu g/cm^2$). This potential for increased worker exposure with an increase in DFR has been investigated and shown to be correlated[7,8,9].

Abamectin or avermectin B1 miticide/insecticide is a mixture containing $\geq$80% avermectin B_{1a} and $\leq$20% avermectin B_{1b}. Abamectin is a general use pesticide and has been evaluated on a variety of commercially grown ornamental plants. Abamectin is sold as an emulsifiable concentrate insecticide for ornamental use. A category II pesticide carrying the signal word "warning," it has a restricted entry interval of 12 hours.

Greenhouse production of plants is labor intensive and some crops require frequent pesticide applications with an inherent increase in likelihood of workers contacting recent residues. While reduced-volume spray technologies have been shown to increase foliar deposition, this result implies a reduction in the amount of pesticide applied to achieve efficacy. This study compares the DFR levels of a conventional application with that of an electrostatic sprayer.

Material and Methods

The application equipment included an electrostatic sprayer manufactured by Electrostatic Spray Systems and a conventional hydraulic sprayer. The electrostatic sprayer is commercially available and the spray wand is equipped with an air atomizing spray head, induction charging with battery pack and compressed air attachment. The ES sprayer produces droplets 30 to 60 microns in diameter with an air line pressure at 40 psi, air volume of 10 CFM and a liquid pressure less than 15 psi. The droplet charge to mass ratio is about -6 mC/kg. The wand is approximately 30 inches in length. The air atomizes the charged droplets as it comes out the spray head that has two orifices. The conventional application was made using a hand wand 30 inches long, equipped with two nozzles placed inline four inches apart at the end of the wand. The two nozzles were marked B-7 manufactured by Yamahoind Company having three orifices each and operating at a pressure of 300 psi.

One “glass-covered” greenhouse was used for the treatments. The greenhouse consisted of four bays each bay measuring 41 x 198 feet with a nook off the end of the north most bay that was also used for plant beds. There were eight beds per bay running east to west with a five foot center aisle down the middle of the greenhouse. Two bays separated the two treatment areas. Each application treated half the greenhouse and the plots sampled were at opposite ends of the greenhouse. The sampling for the ES application took place in the northwest corner and for the conventional application sampling was located in the southeast corner of the greenhouse.

Application information for the product Avid (EPA #618-96), an emulsifiable concentrate containing 1.9% abamectin (0.15 pounds abamectin per gallon), is reported in Table 1. The application rates were those commonly used by the grower. Applications took place between 9 am and noon after the workers completed the harvesting of flowers in the greenhouse. The application order was conventional sprayer then ES. For the applications the applicator made one pass for each side of the row. From the center aisle the applicator walked up between the planted beds spraying one side of the bed and would then turn around to spray one side of the adjacent bed walking back out to the center aisle. For the ES the average time to spray one side of the bed was 34± 3 seconds and for the conventional application the average time to spray one side of the bed was 45 ± 7 seconds. No drift was observed while visually monitoring the application. Sampling began four hours after the last application and was followed up with re-sampling at one, two and six days. Plant rows were watered by drip irrigation during the study period.

Table 1.
Abamectin Application Information[\a]

Application type	Abamectin pounds a. i.	Amount of tank mix applied (gallons)	Tank mix analysis (%)
Electrostatic gun	0.0058	1.25[\b]	0.023
Conventional sprayer	0.0094	90[\c]	0.0015

\aEach treatment was to one half the greenhouse (17,000 sq. ft.).
\b ES Avid rate in mix tank was 5 ounces in 2.5 gallons (2.6 grams a.i.)
\c Conventional Avid rate in mix tank was 8 ounces in 100 gallons (4.2 grams a.i.).

DFR sampling was conducted according to established procedures[10,11]. For the sites sampled, a 2.523 cm diameter Birkestrand leaf punch was used to take the samples and each sample consisted of 40 punches with five samples per interval. Punches were taken along the plant row throughout the plant canopy. All leaf discs were collected in four-ounce glass jars attached to the punch. Each sample jar was capped with a Teflon-lined lid, labeled, bagged, and placed on ice in an insulated chest. Samples were shipped on ice to the California Department of Food and Agriculture (CDFA), Center for Analytical Chemistry laboratory the day of collection.

CDFA Center for Analytical Chemistry performed the analysis for abamectin in DFR extracts. Leaf disks were shaken for thirty minutes with 50 mLs distilled water and 0.2 mL sodium dioctyl sulfosuccinate, decanted and shaken two more times with distilled water. The combined amount of water was extracted three times using 50 mL ethyl acetate. The organic extract was dried by anhydrous sodium sulfate. Derivatization requires reducing 5 mL of the extract to dryness by placing in a silanized test tube and using an Organomation apparatus. The derivatizing solution was prepared by adding 0.6 mL 1-methylimidazole to 5.4 mL N, N-dimethylformamide, chilling in an ice bath, adding 0.9 mL trifluoroacetic anhydride and vortexing. Each sample had 0.3 mL of derivatization solution added to it. The sample was vortexed for ten seconds, sonicated for 3 minutes and vortexed a second time. Samples were placed in a water bath and an ammoniated methanol solution was prepared. Samples were remove from the bath after 1 hour and 0.15 mL of the ammoniated methanol was added and return to water bath. This was removed from the bath and brought to 4 mL with methanol by adding 3.55 mL MeOH and vortexed. The stability of these extracts is sufficient for timely analysis (5% loss per week).

Samples were analyzed by liquid chromatography on a Hewlett-Packard 1050 LC system. Column: 15 cm Econosphere C8 Alltech cartridge system, 30 C, at 1-1.5 mL/min (programmed flow). Gradient: (acetonitrite/water %) 10/90 to 35/65 at 2 min, to 75/25 at 13 min, reset to 10/90, stop at 16 min. Flow Program: 1 mL/min for 5 min, step to 1.5 mL/min at 5.1 min, hold 1.5 mL/min until 13 min, programmed slow down to 1 mL/min at 16 min. This program maintains column pressure at 120-135 bar, and shortens analysis times. Injector: 100 µL using an injection program, draw 100 µL/min from air at max µL/min, eject 100 µL in sample at max µL/min, draw 100 µL from sample at 200 µL/min, inject. Detector: HP 1046 Fluorescence Detector, 364 nm excitation, 480 nm emission, 370 nm filter, photomultiplier 14, lamp strobe 110 Hz. Standards were introduced periodically during the analysis. The limit of detection for abamectin was 0.03 µg per sample. Recoveries from fortifications at 0.8 and 4.0 µg/sample were 85 - 95%. Reproducibility of standard solutions was +/- 5% or less. Data were not corrected for recovery.

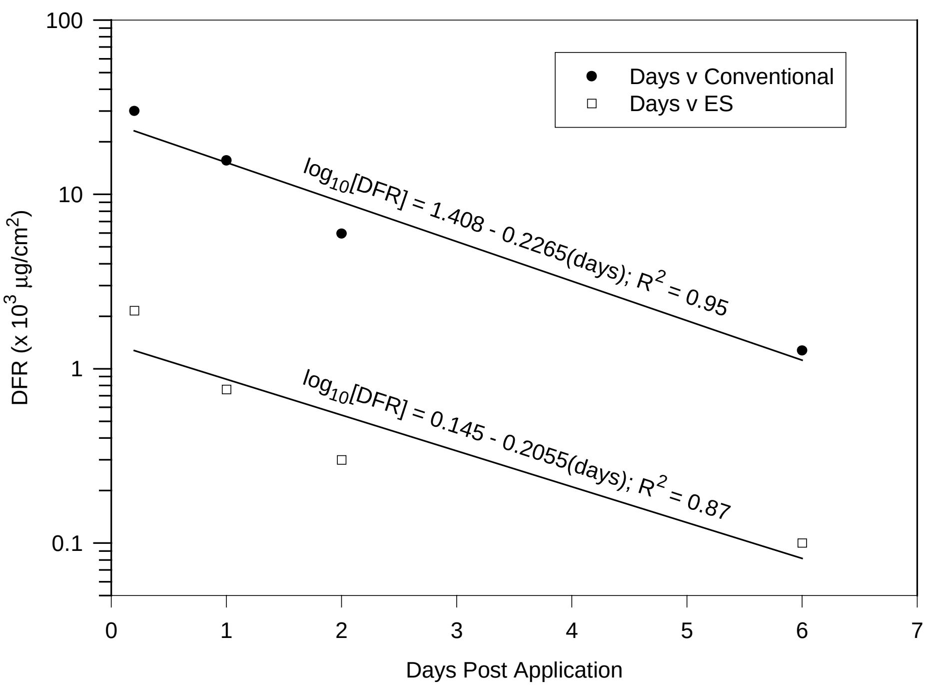
Analytical results reported in micrograms per sample were divided by the surface area of the leaf punches (400 square centimeters). Descriptive statistics were developed using Microsoft® Excel 97 SR-1 , Microsoft Corporation. The graph and regression analysis was performed using SigmaPlot® scientific graphing software version 2.0 , Jandel Corporation.

The protocol for project 9603, “Comparability and differences of dislodgeable foliar residues following reduced-volume and conventional pesticide applications in greenhouses” was approved and signed by the Study Director and Quality Assurance Officer on 22 April, 1998. The study followed applicable branch standard operating procedures for sampling and reporting of data. The experiment began on 2 June 1998 and terminated on 9 June 1998.

Results

Figure 1 shows the empirical decay rate of DFR for the two applications. Linear regressions were performed on the common log of the data for each treatment for the four sampling intervals. There was a significant difference between treatments at p=0.00005. The deposition of the conventional application was significantly higher than the ES application at α 0.01. Half-life data for the two applications were similar at 1.5 days. Means and standard deviations for each sampling day are reported in Table 2. The observed data from each treatment are plotted in Figures 2 and 3. The raw data can be found in Appendix 1.

Figure 1
Dissipation of Abamectin Dislodgeable Foliar Residues



Discussion

Application rates were those commonly used by the grower. Using Table 1 tank mix analyses to calculate the amount of abamectin applied over the treated area there was about 2½ times more applied during the conventional application than the ES application. Initial DFR levels from the conventional application was about twelve times higher than the ES application. Plant height and foliage densities were similar for both types of application equipment. While the ES does have the air assist to aid in penetration of the plant foliage the coarse spray applied to runoff used in the conventional application achieved better penetration of the dense basal tufted leaves of the gerbera plant. In retrospect because of this dense foliage and the sampling throughout the plant canopy it is possible this contributed to the difference in deposition. For pest control purposes it is not always necessary to penetrate the dense foliage for insect or fungal control.

Table 2
Mean and standard deviation for abamectin dislodgeable foliar residues reported in µg/cm^2

		Application Type	
Days post	N	Electrostatic sprayer	Conventional sprayer
Pre	5	$0.26 \pm 0.0001 \times 10^{-3}$	$0.35 \pm 0.07 \times 10^{-3}$
0.2	5	$2.41 \pm 0.73 \times 10^{-3}$	$30.35 \pm 6.06 \times 10^{-3}$
1	5	$1.02 \pm 0.22 \times 10^{-3}$	$15.99 \pm 6.48 \times 10^{-3}$
2	5	$0.56 \pm 0.22 \times 10^{-3}$	$6.30 \pm 3.81 \times 10^{-3}$
6	5	$0.36 \pm 0.09 \times 10^{-3}$	$1.62 \pm 0.4 \times 10^{-3}$

Figure 2

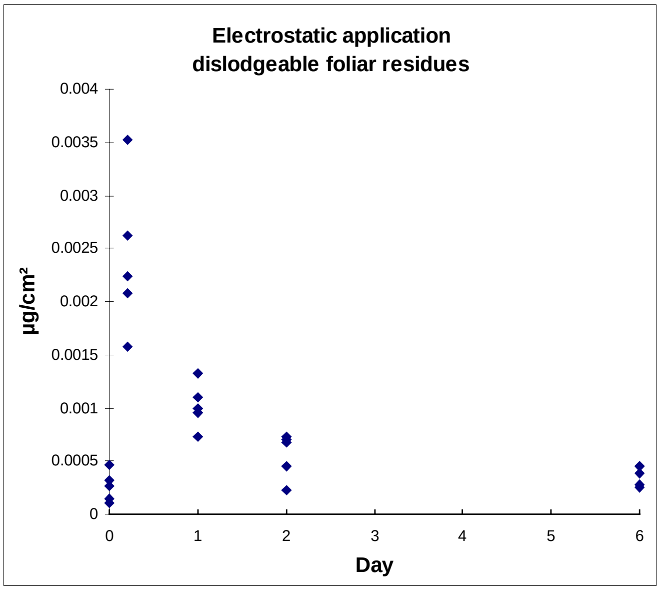
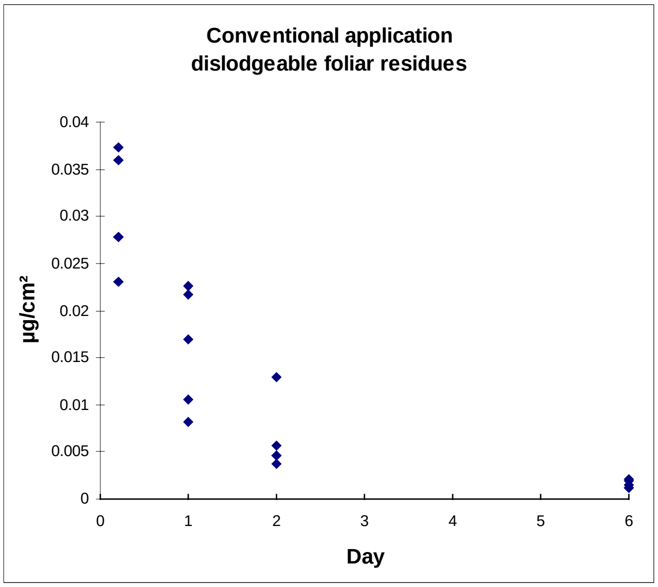


Figure 3



The flowers are harvested about every two days and workers did enter the greenhouse during the six-day study period. During our study workers wore long sleeve shirts and long pants while harvesting flowers before the applications took place but were not wearing gloves. The workers had no contact with the gerbera leaves only the stem and flower of the plants. The stem is about two feet long and the worker would grab the stem with their fingers a few inches below the flower and give a slight twist breaking the stem away from the base of the plant. They would cradle the stems of several harvested flowers in their other arm until they gave them to another worker working at a table who would cut the stems to a specific length. Thongsinthusak, et al. (1990)[12], calculated an abamectin dermal exposure to workers in greenhouses at 28 µg/person/day using a DFR level of 0.01 µg/cm^2. Their dermal exposure was calculated with the workers wearing latex gloves. If all other exposure factors remained the same hand exposure may cause some increase in overall potential dermal exposure over that estimated by Thongsinthusak.

Quality Assurance Statement

The study “Abamectin Dislodgeable Foliar Residues Following Reduced-Volume and Conventional Pesticide Applications in a Greenhouse” followed Worker Health and Safety protocol “Comparability and differences of dislodgeable foliar residues following reduced-volume and conventional pesticide applications in greenhouses”, project number 9603. The resulting data and study report were audited on October 1-4, 1999, 1999 and reported to the study director and branch management on October 6, 1999.

[original signed by K. Orr]

Kathy Orr, Quality Assurance Officer
Worker Health and Safety Branch

Date

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Appendix 1

	Conventional treatment		Electrostatic treatment	
Interval (Day)	Result ug	µg/cm²	Result ug	µg/cm²
0	0.17	0.00041	0.19	0.00047
0	0.15	0.00037	0.11	0.00027
0	0.16	0.0004	0.13	0.00032
0	0.13	0.00034	0.04	0.00011
0	0.10	0.00024	0.06	0.00015
0.2	9.20	0.023	1.05	0.00262
0.2	14.90	0.03725	0.90	0.00224
0.2	14.40	0.036	0.63	0.00158
0.2	11.10	0.02775	0.83	0.00208
0.2	11.10	0.02775	1.41	0.00353
1	3.28	0.0082	0.44	0.0011
1	4.20	0.0105	0.29	0.00073
1	8.66	0.02165	0.53	0.00133
1	6.79	0.01698	0.38	0.00095
1	9.05	0.02263	0.40	0.001
2	2.27	0.00568	0.28	0.0007
2	1.48	0.0037	0.29	0.00073
2	1.83	0.00458	0.18	0.00045
2	1.82	0.00455	0.09	0.00023
2	5.20	0.013	0.27	0.00068
6	0.50	0.00125	0.15	0.00038
6	0.62	0.00155	0.18	0.00045
6	0.50	0.00125	0.18	0.00045
6	0.77	0.00193	0.10	0.00025
6	0.85	0.00213	0.11	0.00028